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The Commtech Methodology: A Demand-Driven Approach to Efficient, Productive, and Measurable Technology Transfer and Commercialization

Gary A. P. Horsham
Glenn Research Center, Cleveland, Ohio

June 1999

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Gary A. P. Horsham
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THE COMMTECH METHODOLOGY: A DEMAND-DRIVEN APPROACH TO EFFICIENT, PRODUCTIVE, AND MEASURABLE TECHNOLOGY TRANSFER AND COMMERCIALIZATION

Gary A. P. Horsham
NASA Glenn Research Center
Cleveland, Ohio 44135

INTRODUCTION

In an era of shrinking high-risk private sector research and development expenditures there is an increasing dependence on government long-term technology development. Public to private technology transfer is steadily becoming a critical, strategic component of U.S. economic growth - both aerospace and non-aerospace. The National Aeronautics and Space Administration's mission is to develop aeronautical and space technologies and explore the frontiers of space. It is also NASA's mission to actively seek out non-aerospace industries and companies with technological problems or needs that might benefit from the transfer or application of its special, state-of-the-art aerospace capabilities. Where it is within NASA's capability, the agency will help companies eliminate shortages of knowledge or solutions, and possibly show the way to technological competitive or strategic advantage. In this regard, the agency plays an important role, along with other public sector technology producers, in contributing long-term, high-risk R&D inputs that help stimulate investment and growth in the U.S. economy. The NASA Commercial Technology Team (1994) established a new, non-aerospace commercial technology policy has been used as the guiding basis for the development of this methodology.

The Commercial Technology Consultants program (abbreviated to "CommTech" program) was developed and applied by NASA Glenn Research Center in Cleveland, Ohio. This paper presents a comprehensive review and assessment of the program's demonstration or pilot cycle - from its conception and initiation in early to mid-fiscal year 1995, and planned activities extending roughly three years into the future. Market research sources were used to initially gather primary technological problems and needs data from non-aerospace companies in three targeted industry sectors: environmental, surface transportation, and bioengineering. Company-supplied information served as input data to activate or start-up an internal, phased matchmaking process. This process was based on technical-level relationship exploration followed by business-level agreement negotiations, and culminated with project management and execution. Space Act Agreements represented near-term outputs. Company product or process commercialization derived from NASA Glenn support and measurable economic effects represented far-term outputs. The paper begins with an overview of the program's objective followed by an overview of the input/output model. A description of the core development and implementation strategy is presented next. This is followed by a presentation of the overall results of the implementation phases. Finally, the program's performance and comparative metrics are summarized and conclusions are drawn.

GOALS AND OBJECTIVES

The goal of this initial CommTech program cycle was to demonstrate the potential low-cost/high productivity advantages of a demand-driven technology transfer model. If successful, then this "technology pull" approach could perhaps complement or be a complete substitute for the "technology push" methods that had been employed throughout the agency to date. In practice, CommTech would apply a "company-led" strategy to systematically foster, track and measure the establishment, development and execution of 1 to 2-year relationships between non-aerospace companies and Glenn scientists and engineers (referred to in this report as "lead participants").

The CommTech program was conceived on the premise or understanding that:

- public to private technology transfer driven by private sector "market" demand (or pull) is potentially more efficient and productive than traditional technology "push" approaches;

- public to private, value-added technology transfer accrues best when public technologies/capabilities are applied to private sector problems/needs whose solutions are either limited or beyond current industry capabilities;

- most companies that operate in non-aerospace industry sectors are generally unfamiliar with NASA technologies and are not in the NASA/Glenn communications loop; and

- public sector entities operate under general policy guidelines that prohibit the offering of services, which are already supplied in the marketplace by private or privatized sources.

Based on all the above, the program was developed with the four-fold objective to:

- Enhance Glenn's position as an accessible national technological resource for all tax-paying, "for-profit" companies in the United States regardless of location;

- Pro-actively identify companies with product/process technology development problems/needs that are beyond the commercial state-of-the-art, and which (to the best of a company's and Glenn's combined knowledge) have a low or zero potential of being met in the commercial supplier marketplace;

- Increase the establishment of high quality non-aerospace technology transfer relationships via a controlled, structured process with clearly defined near and far-term deliverables, including clear program entry and exit-ways;

- Broaden participation in the Agency's non-aerospace technology transfer mission by providing a clear structure, which accommodates and supports the involvement of Glenn S&E's who have not had the opportunity to participate.

PROGRAM PROCESS OVERVIEW

Figure 1 illustrates the basic eight-step (two staged - explained in the next section) process used to develop start-up and operate the CommTech program.

(1) The NASA Glenn Commercial Technology Office released a request to determine product/process development problems/needs within specially targeted non-aerospace industry sectors (companies). Market research intermediaries were used. (2/3) The intermediaries conducted primary market surveys and (4) forwarded the results to the CTO (CommTech) program manager. Surveys were designed to produce respondents with a high "match potential." Care was taken to limit company expectations since it was known that CommTech would only accommodate the interests of a few company respondents (depending on the size of both the companies' and lead participant responses) per cycle. (5) The survey results were then used as input data for an internal Glenn activity that identified individual scientists and engineers. (6) Interested S&E's admitted into the program proceeded to engage companies to further understand their needs. If requested, program funds were used (at the discretion of participating S&E's) to demonstrate their capabilities to companies that were unfamiliar with Glenn. Every effort was made to avoid subsidizing private sector commercial interests. (7) If commercial potential were apparent, then a company would be expected to fund the transfer "Space Act Agreement" (mechanism) needed to realize that potential. (8) The expectation was that companies that participated would eventually produce and commercialize new (or improved) products or processes. These would incorporate enabling or unique, state-of-the-art support and/or technological contributions directly traceable to NASA Glenn.

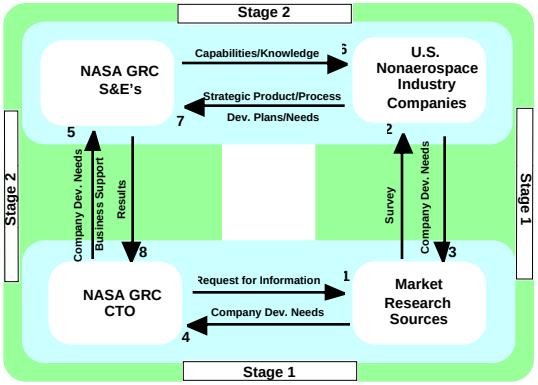

Figure 1. Start-up and process model.

DEVELOPMENT AND IMPLEMENTATION STRATEGY

Program development and implementation was conducted in two stages. Figure 2 portrays the two-staged process schedule and all necessary activities and outputs. Stage 1 consisted of six key activities and was directed toward the development, packaging and release of a program plan and a four-part compilation (appendix) of company needs. Stage 2 consisted of four phases with the ultimate objective to match specific company needs with Glenn capabilities and then establish and execute agreements. The four phases of stage 2 were entitled: I - Response and Participant Selection, II - Company Relationship Exploration, III - Relationship Definition and Agreement, and IV - Agreement Implementation and Execution. The estimated duration of both phases II and III had a built in slack of about 3 months considering the inherent uncertainty associated with accomplishing those objectives. Essentially, the rate at which a lead participant transitioned from phases II to phase III, and then finally to phase IV, largely depended on a particular company's pace. Although it is implied that companies were aware of the CommTech process, this was not the case. For this first program cycle, the process described in this report was only known internally within NASA Glenn by those familiar with the program plan (mainly prospective and eventually only lead participants).

Program Development - Stage 1

As indicated earlier, the objective of stage 1 was to prepare a program plan and develop the accompanying appendix of company needs required for use during phase I of stage 2. The program plan was designed to present a comprehensive, end-to-end description of the program and attract the interest and commitment of Glenn scientists and engineers' in becoming lead participants. A three-part application was included within the plan for the convenience of any prospective participant (i.e., scientist or engineer) to apply for entry. The availability of an appendix with descriptions of company problems/needs (discussed below) enabled any interested scientist and/or engineer to apply and compete in phase I for entry into CommTech's key external interaction phases (II, III, and IV). Phase I was competitive since a pool of limited funds (to be used only for technology/capability demonstrations) had to be allocated to each applicant selected to participate in phase II. A total of $230K was budgeted to support requests from high potential companies/clients for technology/capability demonstrations during phase II.

The NASA Technology Transfer Network members consisting of the Far West Regional Technology Transfer Center (RTTC), the Mid-Continental RTTC, the Southeast RTTC, the Mid-West RTTC, the Mid-Atlantic RTTC, the Northeast RTTC, and Research Triangle Institute, were used to supply primary market research data. Each network member was tasked to

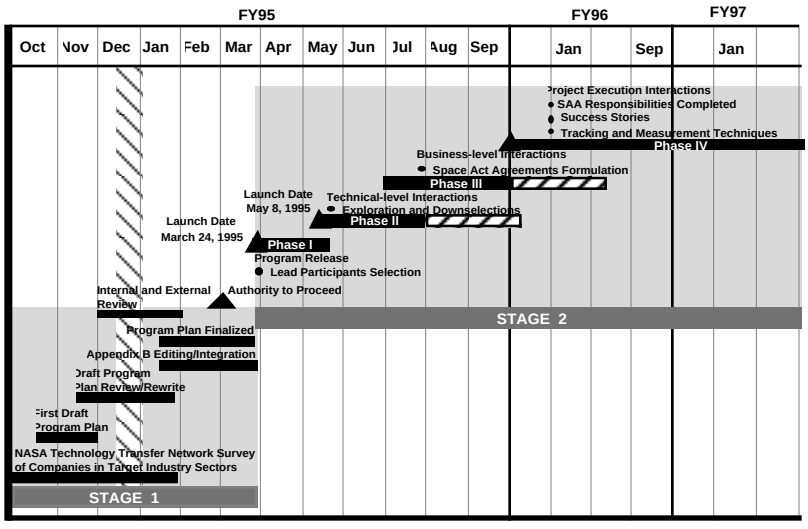

Figure 2: Two-staged development and implementation schedule.

identify 45 companies (from within their respective region's environmental, surface transportation, and bioengineering industry sectors), and obtain descriptions of technology problem or needs. In addition, both business- and technical-level points-of-contact were sought for each company.

Companies from within the environmental, surface transportation, and bioengineering industry sectors were the main focus of this first program cycle. These industries were thought to have companies with high potential synergies with Glenn technologies. Both written correspondence and telephone survey instruments were specially developed and employed. Written surveys provided a basic, comprehensive outline of NASA Glenn's areas of technology expertise. This helped companies make preliminary assessments about the potential applicability of NASA Glenn's aerospace technologies/capabilities - and increased the "match potential."

Over 350 companies provided information about their special (proprietary or non-proprietary) product/process development problems or needs. In addition, they also indicated which Glenn technologies/capabilities areas they thought might best serve their needs. All survey results were forwarded to the Glenn program manager. Following receipt of the raw data, a program plan and four-part appendix of company needs were finalized. In total, the final package contained 212 pages: 25 pages for the program plan and 187 pages for the complete appendix. The appendix contained 142 company technology needs profiles, and was produced primarily to enable applicants without any previous non-aerospace technology experience to participate (and compete) in the phase I process.

Program Implementation - Stage 2

Stage 2, the implementation stage, commenced on March 24, 1995. After receiving the program package in phase I, interested scientists/engineers responded by completing the three part application. During this phase I application process, all applicants were provided with company names and technology needs descriptions - no specific names of technical points-of-contact were given to avoid any premature interaction. Applicants qualified for phase II through the phase I process based mainly on a measure and comparative analysis of the level of commitment and interest indicated in their application.

The first part of the application required applicants to choose six companies from the appendix of company needs. The choice of six companies was an arbitrary figure, neither too few nor too many, and was used to increase the chances for success in phase II. The majority of applicants submitted required six choices, however a few submitted less. Applicants who were presently supporting companies or had previously worked with companies on their own had the option to enter up to three of those companies (i.e., if they fell into one of CommTech's target industry sectors). The other two parts of the application gathered additional information to help gauge each applicant's preparedness to participate, and the degree to which he/she might reliably commit time toward completing the objectives of stage 2 - phases II and III, and most importantly phase IV.

At this point, a lead participant choice of companies in phase I became one of the more important factors (among others) for success. In phase II, a lead participant's ability to quickly understand a company's particular non-aerospace culture, communicate and follow through effectively, was another factor for success. Most importantly, a company's assessment of (and/or ability to assess) the participant's proposed technology/capability match was critical. Even with the maximum six companies to help reduce the odds, it was challenging for most participants to complete phase II.

At the start of phase II, each lead participant was given market-need information (as provided in the appendix) about each of his/her chosen companies. Several participants selected some of the same companies in phase I. It was therefore necessary to incorporate a high degree of inter-participant coordination into phase II. This prevented participants from contacting companies in an awkward, haphazard, or uncoordinated manner. To accomplish this, each participant was informed about the specific company choices of all other participants that happened to coincide with their own. Phase II was subsequently kicked off and the "virtual marketplace" of technical-level communications between the participants and technical points-of-contact at each company became active. The virtual technology marketplace of potential buyers and sellers is depicted in figures 3 and 4. It was originally intended that lead participants would travel and visit high potential companies at some point during their respective phase II processes. However, due to the absence of travel funds, only telephone, electronic, and other non-physical means were available.

In phase II, lead participants used the limited information provided in the appendix to get a preliminary sense of their companies' needs in order to prepare for introductory discussions with the respective

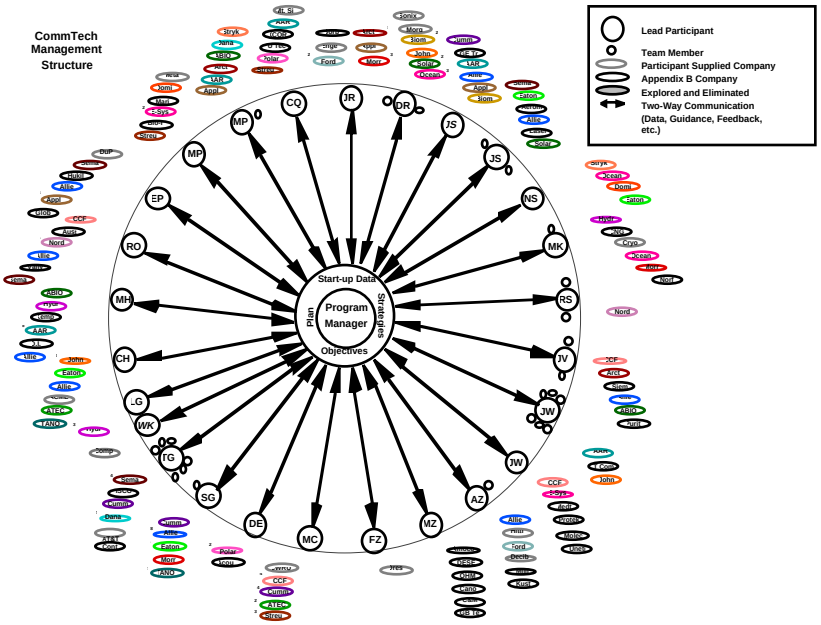

Figure 3: Phase II virtual start-up configuration.

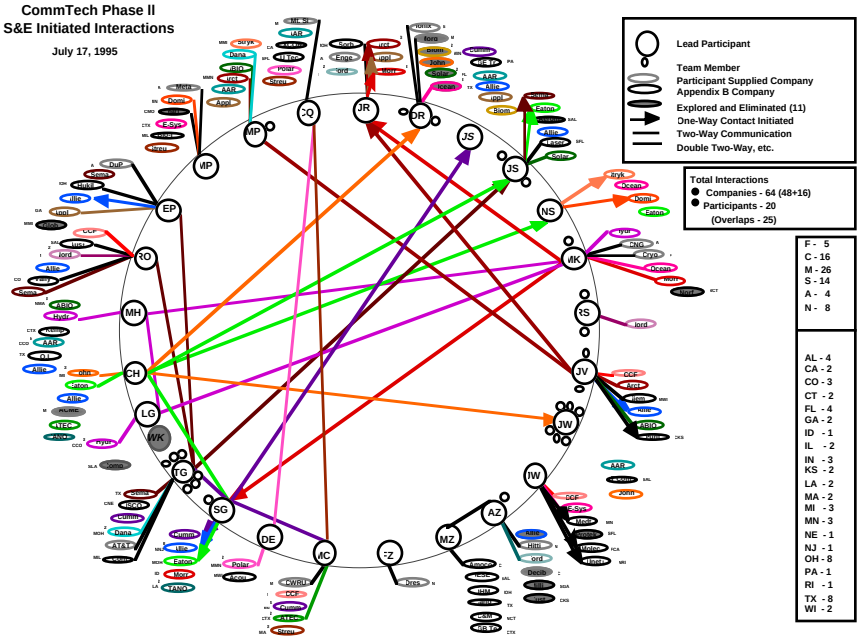

Figure 4: Virtual marketplace activity near the planned Phase II to Phase III transition point.

technical points of contact. The aim of this initial conversation was to quickly develop a more in-depth technical understanding of a company's product/process development needs - and vice-versa for the company. Each lead participant (together with his/her company technical point-of-contact) used this deeper understanding to make a rapid and accurate assessment of whether his/her particular technology and/or capabilities might match a company's need. The telephone interactions with companies were done according to a sequential contact strategy to avoid raising (any company's)

expectations that could not be met. Therefore, when a match was found, the participant would cease his/her sequential contact process at that point. Further telephone contacts occurred only if the lead participant were willing to assume the additional responsibility that would result from the discovery of another match. Capability demonstrations were provided at a company's request if the lead participant thought the interaction held promise – and funds were available. These demonstrations were paid for as needed with the lead participant's CommTech funds allotment. Although phase II had a planned duration of three months, it was expected that in many cases it would be necessary to extend this phase for an additional three months to allow slower-to-develop relationships to coalesce. Similar reasoning was applied to phase III.

After a "technical" match between technology need and capability (or demand and supply) was secured, discussions shifted to the "business" level. In other words, phase II transitioned into phase III. In phase II, those participants who were fortunate enough to discover a company whose needs matched their capabilities proceeded to phase III. Those who did not terminated their participation in the program with a clear and measurable effort and contribution to show for it. Phase III ended, on an individual basis, when NASA and a particular company officially signed a formal Space Act Agreement. This agreement represented NASA's legal obligation to deliver specific technologies/support to that company at a specified cost and schedule.

Phase III participants who successfully negotiated and established an agreement transitioned into phase IV. Phase IV had a planned duration extending through fiscal year 1997. Here, the participant's ability to deliver on his/her commitment became critical. The challenge all lead participants faced at this point was incorporating scheduled, non-aerospace support obligations into their "higher priority" aerospace work schedules.

In addition to the success/risk factors mentioned with respect to phase II above, it was recognized that overall success during stage 2, in particular phase IV, depended largely on the degree of relevance or importance each lead participant's functional manager attached to non-aerospace interactions. This constituted an additional risk factor that in several cases may have negatively impacted the performance and output of stage 2.

RESULTS OF IMPLEMENTATION PHASES

Twenty-six (26) scientists/engineers responded to the phase I solicitation. Of these, 16 applied as individuals and 10 as teams. In addition, 9 applicants had experience in non-aerospace technology transfer while 17 had no experience. These applicants selected a total of 73 companies to explore in phase II of which 58 (or 79 percent) were chosen from the appendix, and 15 (21 percent) were included by some experienced applicants. Figure 5 provides additional aggregate information on industry sectors and regional sources.

Figure 6 portrays the cumulative totals and the various rates at which the scientists and engineers initiated their company interactions during phase II. As shown, 125 out of a possible maximum of 128 (or 98 percent) company interactions (the total count resulting from the

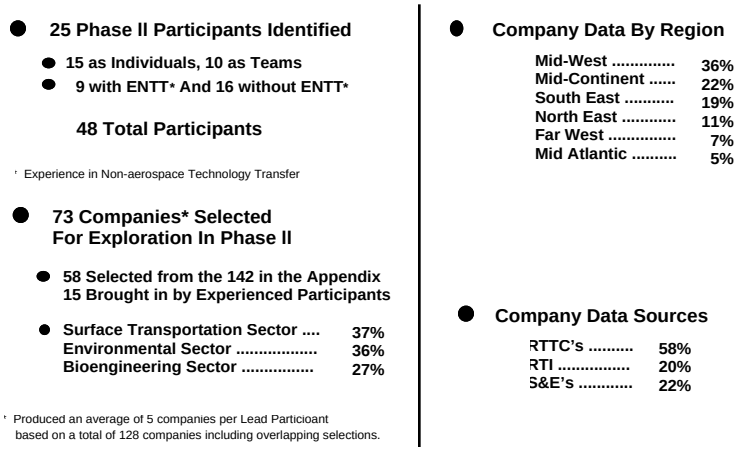

Figure 5: Summary of Phase I aggregate input/output results.

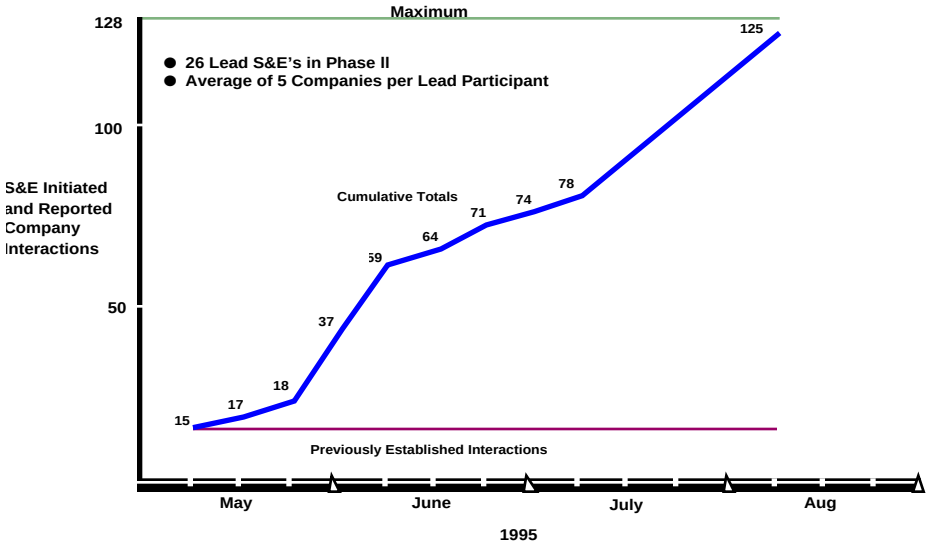

Figure 6: Phase II effort expended, and rate of expenditure, by participating scientists and engineers.

overlapping selections of the same company by different participants) were recorded by August 7, 1995. At the end of phase II, eleven (11) lead participants had successfully established relationships, which could be transitioned into, phase III.

The development and completion of technical-level discussions varied widely from participant to participant. As a result, the transition from phase II to phase III was managed on a case-by-case basis, since each participant progressed at a different rate due to differences in company (organizational) interface structures. Out of the initial 26 lead participants who entered phase II, and the eleven who progressed to phase III, four Space Act Agreements were established. Basically, one agreement was generated for every 6.5 participants that entered the program in phase I.

As mentioned previously, it was expected that a large fraction of lead participants would not progress from phase II to phase III. For that matter, even fewer were expected to progress from phase III to phase IV. It must be emphasized though, that the lack of success in phases II or III did not constitute failure. That is why one of the critical measures used in recording CommTech's overall performance was the effort expended by all participants during phases II and III.

Results for phase IV in the form of success stories based on market introduction of derived products/processes, commercialization activities, etc., are not yet available.

Performance Measurement Technique Formulation

As indicated earlier, tracking and measurement techniques would be devised in phase IV. In that regard, the private/public investment ratio was formulated to provide a future means of providing cycle to cycle performance comparisons. It was found that it would be useful for the CommTech program to have a single overall program performance metric that could be used as a general performance indicator or index.

The private/public investment ratio (PPIR) is written as:

$$PPIR = I_{Private} / I_{Public}$$

where:

$I_{Private}$ = The total "private dollar investment" in one or more technology transfer and commercialization objectives;

and,

I_{Public} = The total "public dollar investment" in one or more technology transfer objectives.

If the process of demand driven technology transfer and is considered a "production" process, then $I_{Private}$ and I_{Public} can perhaps be determined from the following two equations. (The specific functions

represented by each term in each equation, along with the relevant or associated stage 2 phases, are given in parentheses below):

$I_{Private} = A + f_l H_l W_l \sum L_h + f_e H_e W_e \sum E_i + f_p H_p W_p \sum P_j + f_m H_m W_m \sum M_k$

{$I_{Private}$ = Transfer (phase III)+ Transfer (phase III)+ Transfer (phase II/IV)+ Transfer & Commercialization (phase IV)+ Commercialization (post phase IV)}

and,

$I_{Public} = D + f_m H_m W_m \sum M_k + f_e H_e W_e \sum E_i + f_l H_l W_l \sum L_h$

{I_{Public} = Transfer (phase II)+ Transfer (stage l/phase I)+ Transfer (phase II)+ Transfer (phase III)}

where the stated "labor" and "capital" "factors of production" and their associated "price" determinants are described by:

A = The private dollar amount committed to fund an established (Reimbursable or Cooperative) Space Act Agreement;

D = The public dollar amount expended to provide a capability demonstration to a particular company;

$f_{(l, e, p, or m)}$ = Inflation factors to adjust each term;

$H_{(l, e, p, or m)}$ = The number of hours needed to perform each of the key functions, respectively;

$W_{(l, e, p, or m)}$ = The hourly wage rates of each respective functional area (as a function of government, company or industry origin);

L_h = The number of legal personnel needed to establish the technology transfer agreement;

E_i = The number of engineering personnel needed to demonstrate and/or transfer the technology (public and private); and/or to incorporate the transferred technology into a new or existing product design (private);

P_j = The number of production personnel needed to actually produce the new or modified product (private); and
M_k = The number of marketing personnel needed to promote and introduce CommTech (public); and, position and develop a promotion and pricing strategy for the new/modified product (private).

The two equations are derived from the economic theory of production. The validity of this approach remains to be demonstrated in practice. This of course depends on whether the necessary input data would actually be provided by (any or all) participating companies.

It was beyond the scope of the CommTech program first cycle objectives to gather all the above investment data. As a result, a PPIR based on the simple "A/D" approximation (see Table 1), was determined only to serve as a rough point of departure or baseline. In the future, however, detailed, individual and aggregate PPIR's would need to be estimated during Phase III, and then adjusted and finalized during Phase IV.

It was understood that companies generally tended not to track unpatented/unlicensed technology transfer from source to end product application and commercialization. As a result, a company's technology transfer and commercialization process (cost) data tend to dissipate. Because of this, the required process data (above) would have to be acquired from a company during each relevant phase (II, III, and IV).

RESULTS SUMMARY

Table 1 displays a summary of the metrics resulting from each of the phases in stage 2. As noted previously, the initial 26 phase II participants produced a participant/agreement ratio of 6.5 (based on 4 agreements), or 2.2 with respect to phase III (based on 6 agreements). For all 6 phase III agreements, the cost was $22K per agreement, or $26K per project, with respect to the total $130K (phase II/phase III) for demonstration expenditures.

The private/public investment ratio (PPIR) described in the above section was formulated as a key parameter or metric by which CommTech performance could gauged and compared over time. This ratio was designed to be a measure of the aggregate efficiency of the program - the higher the PPIR, the greater the efficiency. A detailed, first cycle PPIR, however, could not be determined since the methodology was developed as an output of this first cycle for application with future cycles. Instead, a simplified approximation is calculated and given below as a rough performance measure and basis for comparison with future cycles.

Table 1: First cycle Stage 2 summary of results.

		Glenn Participants [1]	Outreach Effort	Companies	Public Investment (D)	Private Investment (A) [5]	Private/Public Investment Ratio [6]	Signed Agreements [7]	Projects [8]	Participant/ Agreement Ratio	Participant/ Project Ratio	Product/Process Applications	Commercialization: Impact
Stage 1				256	$80K [4]								
Stage 2	Phase I	Open [2]		142									
	Phase II	26	125	73	$70K					6.5 [9]	6.5 [9]		
	Phase III	13 [3]		16	$60K			6		2.2	2.6		
	Phase IV	5		5		$200K	0.95		5		1	TBD	TBD

1 Includes 3 new participants who entered the program in FY96.
2 Program was open to all NASA Glenn S&E's - 26 applications were submitted.
3 Eleven (11) from initial 26 phase II participants plus 2 later additions.
4 Market research cost estimate (NASA Headquarters (RTTC's & RTI) contract/task obligation).
5 Includes estimate on all fully negotiated, signed and unsigned FY97 Agreements.
6 Simplified estimate shown based on Private Investment/Public Investment data in Table.
7 Four (4) agreements were generated by the initial 26 phase II participants.
8 Includes estimate on all started and expected FY97 projects.
9 Based on 4 agreements (see note #7).

TBD: To be determined

In a strict sense, technology transfer was considered to have occurred only where phase IV was either in progress or was completed. The information exchanged in the numerous telephone interactions which occurred during phase II were considered a measure of effort only and were not considered technology transfer. In this first CommTech cycle therefore, only five cases of successful technology transfer (or interaction) are recorded.

No commercialization successes have yet been recorded. Commercialization can be defined as the creation and/or modification, and introduction into the marketplace of a product or process. Long (1999) offers some insight into the timeframes, challenges and complexities involved in new product/process technology commercialization. Such timeframes appear to realistically range between 5 and 15 years. Whether the five candidate technology transfer cases mentioned above will achieve commercialization success is largely dependent on the respective companies' market and strategic business interests. In other words, commercialization is in the domain of the private sector.

CONCLUSIONS AND RECOMMENDATIONS

The potential usefulness, broad applicability and measurability of the CommTech methodology were demonstrated. All stated objectives were addressed. The most important factor contributing to success appeared to be the availability of internal R&D funding to support capability demonstrations. As a result, NASA R&D funded technology capability demonstrations (in response to requests from high potential non-aerospace clients) were a built-in, critical component of this first program cycle conducted at NASA Glenn.

If a second, similar or larger scope program cycle is undertaken sometime in the future (within NASA Glenn, another NASA Center, or throughout the entire agency if desired), then the following recommendations or considerations might produce better results:

- The initial program cycle was conducted by one individual serving as program manager. Certain activities in Stage 1 and Stage 2 (phase II and III, in particular) would probably benefit from more specialized and focused support, in this regard.

- The effectiveness of phase II may be improved if the inherent time lag between the discovery of a (product/process) technology problem/need, and the identification and application of an appropriate candidate technology solution, can be reduced. In order to minimize this time lag, the rate at which the formal stage I and stage 2/phase I participant selection processes are accomplished must be accelerated or maximized.

- Company/client awareness of technology capabilities is of particular importance. It is possible that, given more lead-time, combined with more information about CommTech objectives, market research sources might provide more effective support in this area.

- The productivity of this methodology might be increased if lead participants were able to meet with select companies and obtain a face-to-face understanding of their respective problems or needs. The additional travel cost or investment expenditure incurred would probably result in higher quality interactions, which might in turn produce better, more productive relationships.

Finally, the methodology presented in this report appears to be broadly applicable within most public sector technology producing entities – i.e., other government agencies (and perhaps certain private sector entities as well). Presumably, some minor modifications would most likely be necessary, depending on how the particular organization functions and what it wishes to accomplish in the area of technology transfer and commercialization.

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6. AUTHOR(S)

Gary A. P. Horsham

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

National Aeronautics and Space Administration
John H. Glenn Research Center at Lewis Field
Cleveland, Ohio 44135–3191

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This paper presents a comprehensive review and assessment of a demonstration technology transfer and commercialization program called “CommTech”. The program was conceived and initiated in early to mid-fiscal year 1995, and extended roughly three years into the future. Market research sources were used to initially gather primary technological problems and needs data from non-aerospace companies in three targeted industry sectors: environmental, surface transportation, and bioengineering. Company-supplied information served as input data to activate or start-up an internal, phased matchmaking process. This process was based on technical-level relationship exploration followed by business-level agreement negotiations, and culminated with project management and execution. Space Act Agreements represented near-term outputs. Company product or process commercialization derived from NASA Glenn support and measurable economic effects represented far-term outputs.

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